Express Mail Label No.

UTILITY PATENT APPLICATION TRANSMITTAL
(Small Entity)
(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
BSW.007

Total Pages in this Submission
3

JC803 U.S. PTO
09/13/00

TO THE ASSISTANT COMMISSIONER FOR PATENTS
Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

SUPERCONDUCTING TAPES

JC825 U.S. PTO
09/661253
09/13/00

and invented by:

Francis DARMANN et al.

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

☒ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: **PCT/AU99/00179**

Which is a:

☐ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: ______

Which is a:

☐ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: ______

Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 7 pages and including the following:
   a. ☒ Descriptive Title of the Invention
   b. ☒ Cross References to Related Applications *(if applicable)*
   c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
   d. ☐ Reference to Microfiche Appendix *(if applicable)*
   e. ☒ Background of the Invention
   f. ☒ Brief Summary of the Invention
   g. ☒ Brief Description of the Drawings *(if drawings filed)*
   h. ☒ Detailed Description
   i. ☒ Claim(s) as Classified Below
   j. ☐ Abstract of the Disclosure

# UTILITY PATENT APPLICATION TRANSMITTAL **(Small Entity)** *(Only for new nonprovisional applications under 37 CFR 1.53(b))*	Docket No. **BSW.007** Total Pages in this Submission **3**

Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*

   a. ☒ Formal b. ☐ Informal Number of Sheets 1

4. ☐ Oath or Declaration

   a. ☐ Newly executed *(original or copy)* ☐ Unexecuted

   b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*

   c. ☐ With Power of Attorney ☐ Without Power of Attorney

   d. ☐ DELETION OF INVENTOR(S)
   Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).

5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Computer Program in Microfiche

7. ☐ Genetic Sequence Submission *(if applicable, all must be included)*

   a. ☐ Paper Copy

   b. ☐ Computer Readable Copy

   c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☐ Assignment Papers *(cover sheet & documents)*

9. ☐ 37 CFR 3.73(b) Statement *(when there is an assignee)*

10. ☐ English Translation Document *(if applicable)*

11. ☐ Information Disclosure Statement/PTO-1449 ☐ Copies of IDS Citations

12. ☒ Preliminary Amendment

13. ☒ Acknowledgment postcard

14. ☐ Certificate of Mailing

    ☐ First Class ☐ Express Mail *(Specify Label No.)*:

UTILITY PATENT APPLICATION TRANSMITTAL (Small Entity) *(Only for new nonprovisional applications under 37 CFR 1.53(b))*	Docket No. **BSW.005**
	Total Pages in this Submission 3

Accompanying Application Parts (Continued)

15. ☐ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*

16. ☐ Small Entity Statement(s) - Specify Number of Statements Submitted: ____________

17. ☐ Additional Enclosures *(please identify below):*

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra		Rate	Fee
Total Claims	19	- 20 =	0	x	$9.00	$0.00
Indep. Claims	3	- 3 =	0	x	$39.00	$0.00
Multiple Dependent Claims (check if applicable) ☐						$0.00
					BASIC FEE	$345.00
OTHER FEE ***(specify purpose)***						$0.00
					TOTAL FILING FEE	$345.00

☐ A check in the amount of to cover the filing fee is enclosed.
☐ The Commissioner is hereby authorized to charge and credit Deposit Account No. as described below. A duplicate copy of this sheet is enclosed.

- ☐ Charge the amount of as filing fee.
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- ☐ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Dated: **SEPTEMBER 13, 2000**

Susan S. Morse

Signature

SUSAN S. MORSE
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cc:

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re PATENT APPLICATION of

Francis DARMANN et al. [Group Art Unit: Not Assigned]

Continuation of Serial No.: PCT/AU99/00179 [Examiner: Not Assigned]

Filed: September 13, 2000

SUPERCONDUCTING TAPES

PRELIMINARY AMENDMENT

Honorable Assistant Commissioner of Patents and Trademarks,
Washington, D.C. 20231

Sir:

Preliminary to the examination of the above-identified application, please enter the following amendments and remarks.

IN THE SPECIFICATION

Kindly amend the specification as follows:

Page 1, between lines 1 and 2, insert

--CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation application of application Serial No. PCT/AU99/00179, filed March 18, 1999, the entire contents of which are hereby incorporated by reference for all purposes.--

Page 2, line 18, after other, please insert --the composite superconducting tape including at least one tape bridging the stacks--;

between lines 18 and 19, please insert the following new paragraphs --According to another aspect of the invention, there is provided a composite superconducting tape constructed from a plurality of superconducting tapes, each having two opposite major faces and two opposite edges extending between the major faces, the composite superconducting tape including a first stack having a plurality of the superconducting tapes wherein each tape in the first stack has at least one major face in contact with a major face of an adjacent superconducting tape in that stack, a second stack having a plurality of the superconducting tapes wherein each tape in the second stack has at least one major face in contact with a major face of an adjacent superconducting tape in that stack, wherein at least some of the superconducting tapes have widths not greater than half the width of the composite superconducting tape, and a bridging tape spanning between the two stacks for maintaining the first and second stacks in a substantially parallel edge-to-edge configuration.--

IN THE CLAIMS

Please note that there was no claim 6 presented in the original application. Therefore, claim 6 is not pending.

Please cancel claim 10 without prejudice thereto or disclaimer to subject matter

therein.

Please amend the claims as follows:

1. (Amended) A composite superconducting tape comprising a multiplicity of constituent superconducting tapes stacked parallel to one another with major faces in contact [and characterized in that], wherein at least some of the constituent tapes have widths not greater than half the width of the composite superconductor and are laid edge-to-edge with each other, the composite superconducting tape including at least one tape bridging the stacks.

4. (Amended) A composite superconducting tape as claimed in [any one of claims 1-3 comprising] claim 1, wherein the at least one [full-width] bridging tape is the full width of the composite superconductor and is produced from a silver or silver alloy material [bridging from tape to tape].

7. (Amended) A composite superconducting tape as claimed in claim [6 in which] 5, wherein the two metal tapes are of unequal strength.

Please add the following claims.

--11. A composite superconducting tape constructed form a plurality of

superconducting tapes each having two opposite major faces and two opposite edges extending between the major faces, the composite superconducting tape including:

a first stack having a plurality of the superconducting tapes wherein each tape in the first stack has at least one major face in contact with a major face of an adjacent superconducting tape in that stack;

a second stack having a plurality of superconducting tapes wherein each tape in the second stack has at least one major face in contact with a major face of an adjacent superconducting tape int hat stack, wherein at least some of the superconducting tapes have widths not greater than half the width of the composite superconducting tape; and

a bridging tape spanning between the two stacks for maintaining those stacks in a substantially parallel edge-to-edge configuration.

12. A composite superconducting tape as claimed in claim 11, wherein all the constituent superconducting tapes have a width that is substantially a simple fraction of the width of the composite tape so that they form two or more substacks with aligned zones between them which contain no superconducting material.

13. A composite superconducting tape as claimed in claim 12, wherein said simple fraction is a half, so that there are two sub-stacks.

14. A composite superconducting tape as claimed in claim 11, wherein the at least one bridging tape is the full width of the composite superconductor and is produced from a silver or silver alloy material.

15. A composite superconducting tape as claimed in claim 14, wherein two full-width metal tapes are present, one at each end of the stack.

16. A composite superconducting tape as claimed in claim 15, wherein the two metal tapes are of unequal strength.

17. A composite superconducting tape as claimed in claim 11, wherein the superconducting tape is diffusion-bonded and all its elongate components extend longitudinally.

18. A composite superconducting tape as claimed in claim 11, in which the constituent tapes are all powder-in-tube superconducting tapes.

19. A method for producing a composite superconducting tape constructed from a plurality of superconducting tapes each having two opposite major faces and two opposite edges extending between the major faces, the method comprising:

providing a first stack having a plurality of the superconducting tapes wherein

each tape in the first stack has at least one major face in contact with a major face of an adjacent superconducting tape in that stack;

providing a second stack having a plurality of superconducting tapes wherein each tape in the second stack has at least one major face in contact with a major face of an adjacent superconducting tape in that stack; and

providing a bridging tape for maintaining the two stacks in a substantially parallel edge-to-edge configuration wherein at least some of the superconducting tapes have widths not greater than half the width of a composite superconducting tape.

20. A method according to claim 19, further comprising rolling the composite superconducting tape.--

REMARKS

By this Preliminary Amendment, the specification has been revised to identify the parent application, the claims have been amended to eliminate multiple dependence and clarify the claims, the specification has been amended to correspond to these amended claims, claim 10 has been canceled, and claims 11-20 have been added. Therefore, claims 1-5, 7-9 and 11-20 are pending. Claims 1, 11 and 19 are independent. Entry of this Preliminary Amendment and favorable action on the merits are respectfully requested.

In the event that there are any outstanding matters remaining in the present

application, the Examiner is invited to contact Susan S. Morse (Reg. No. 35,292) at (703) 715-0870 in the Washington, D.C. area, to discuss these matters.

Respectfully submitted,

JONES VOLENTINE, L.L.C.

By: Susan S. Morse

Susan S. Morse
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SSM:tmd

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Date: September 13, 2000

TITLE: SUPERCONDUCTING TAPES

FIELD OF THE INVENTION

The present invention relates to a superconducting tape and more particularly to a composite superconducting tape.

BACKGROUND OF THE INVENTION

The invention has been developed primarily for carrying alternating current and will be described hereinafter with reference to that application. It will be appreciated, however, that the invention is not limited to that particular field of use and is also suitable for carrying direct or non periodically varying current.

Tapes comprising superconducting material, and referred to as superconducting tapes, are already known, and comprise one or many superconducting filaments in a medium of silver or silver alloy. Superconducting tapes are used to make coils, magnets, transformers, motors and generators as well as current carrying cables. The main class of superconducting tape is referred to as powder-in-tube or PiT tape. This tape is made by drawing or otherwise reducing a tube of silver, or less usually silver alloy, which is filled with a powder form of a superconducting oxide. The tube is then subjected to further rolling to form it into a thin tape. Multifilamentary tapes are mostly made by grouping a plurality of filled tubes in a common silver or silver alloy sheath at an intermediate stage of reduction.

One important superconducting oxide is known as Bi-2223. This oxide includes bismuth, strontium, calcium, and copper and, as would be known to those in the art, certain limited substitutions can be made. This oxide can be considered a cuprate salt.

Known tapes usually have a thickness of between around 0.2 mm and 0.3 mm, and a width of between 2 mm and 5 mm. The superconducting filaments must be thin to obtain an adequate critical current. A typical thickness is around 10 to 40 microns. Moreover, a typical aspect ratio is at least 1:10.

The filaments comprise many plate-like grains and, for good performance, the grains should be, as much as possible, aligned in the same crystallographic orientation. The relative orientation is often referred to as the grain alignment or "texture". Thin, well textured filaments allow a high critical current and give overall flexibility to the whole tape.

Composite tapes are sometimes made by forming a stack of individual tapes and wrapping the stack with one or more metal tapes to keep it together. These metal tapes are usually of silver or silver alloy. In U.K. patent application no. 9805641.9 in the name of the same applicant there has been proposed an improved form of composite tape in which the individual tapes are diffusion bonded, eliminating the need for the metal wrapping tape. This allows the elimination of the inevitable gaps and overlapping between the turns of the wrapping tape that create kinks in the filaments that destroy local grain alignment. As foreshadowed above, a reduction in alignment leads to a degradation of the overall critical current density J_c.

DISCLOSURE OF THE INVENTION

It is an object of the present invention, at least in the preferred embodiment, to overcome or substantially ameliorate one or more of the disadvantages of the prior art, or to provide a useful alternative.

According to the invention there is provided a composite superconducting tape comprising a multiplicity of constituent superconducting tapes stacked parallel to one another with major faces in contact, and is characterised in that at least some of the constituent tapes have widths not greater than half the width of the composite superconductor and are laid edge to edge with each other.

Preferably, all the constituent superconducting tapes have a width that is substantially half, or another simple fraction, of the width of the composite tape so that they form two or more substacks with aligned zones between them which contain no superconducting material. This will normally require the addition of a full-width tape of silver or silver alloy to bridge from stack to stack , to provide sufficiently strong mechanical connection between the stacks. Preliminary experiments indicate that this structure has substantially lower AC losses compared with a stack of the same overall dimensions and composition with all full-width superconducting tapes. While the inventors do not wish to be bound by any theory, it is thought that this observation may be accounted for by magnetic de-coupling between the stacks.

Preferably also, the full-width metal tape is at one end of the stack. More preferably, two full-width metal tapes are provided, one at each end of the stack. Even more preferably, if there is only one metal tape or two tapes are unequal strength, that

the metal tape is used in a construction in which the tape, or the stronger tape respectively, is always on the convex side of any curve, as more fully explained in U.K. patent application no. 9805644.3.

In some embodiments one full-width superconducting tape is used.

Preferably, the superconducting tape is diffusion-bonded and all its elongate components extend longitudinally, as described in UK patent application no. 9805641.9.

In a preferred form, a metal tape is used which is flat and has a width not substantially greater than that of the superconducting tapes. In some embodiments the width of the metal tape is slightly less than that of the superconducting tapes. In still further embodiments, however, a wider metal tape is used which is, or subsequently becomes, bent to a channel section. Although the latter arrangement would have structural advantages it would adversely affect fill factor. Similarly, the use of a silver foil or other compatible material wrapped around the stack but extending longitudinally is not excluded.

Preferably, diffusion bonding of the superconducting tapes and, if present, the metal tapes, is achieved by assembling the tapes face to face and heat-treating at a temperature low enough to avoid any deleterious effect on the superconducting material. When the superconducting material has a typical BSCCO-2223 composition, the temperature should not exceed 842°C. Provided control is close enough, a temperature of 840°C is recommended.

A diffusion time at temperature of several hours will be required to achieve adequate bonding. It will be appreciated, however, that excessively long periods are undesirable as tending to produce too much sintering of the superconductor material.

Preferably the diffusion-bonded stack of tapes is rolled to reduce overall thickness and to strengthen the bonding.

Unless the context clearly requires otherwise, throughout the description and the claims, the words 'comprise', 'comprising', and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings (not to scale) in which:

Figure 1 is a cross-section of a composite superconducting tape according to the invention; and

Figure 2 is a cross-section of another embodiment of a composite superconducting tape according to the invention.

PREFERRED EMBODIMENTS OF THE INVENTION

The composite superconducting tape shown in Figure 1 has a width of between 4 and 5.5 mm and a thickness of about 0.27 mm and comprises (for example) eight stacked monofilamentary tapes 12 bonded together. Each monofilamentary tape 12 comprises a filament 5 of superconducting material, for example, BSCCO-2223 in a silver/silver alloy cladding 7 as with known superconducting tapes. Typical, in the finished product as shown, each individual monofilamentary tape 12 has a thickness of 50 μm and the filaments 5 themselves have typical thicknesses of 10 to 40 μm. The constituent tapes 12 each have a width substantially equal to half the width of the composite tape and they are arranged with a full-width silver bridging tape 13 in two sub-stacks 15 with a zone 16 between them that is substantially free of superconductor filaments.

The tape of Figure 2 is similar except that there are silver and/or silver alloy tapes 13 and 14 at both the top and bottom ends of the stack.

To make either of the superconducting multifilamentary tapes shown in the drawings, the required number of monofilamentary tapes 12 must be made. The monofilamentary tapes 12 are made by firstly packing BSCCO-2223 oxide powder (or more usually a precursor convertible to the Bi-2223 composition by heat-treatment) into a cleaned and dry tube of silver or silver alloy having an internal diameter of approximately 8 mm and an external diameter of approximately 10 mm. A length of between 4 cm and 6 cm - depending upon the length of the silver tube - at one end of the tube is then swaged, and the tip of the swaged end closed off using smaller swaging dies, to prevent powder loss during packing. After swaging, the tube is again dried. The prepared tube is then carefully filled with the superconducting powder (precursor) under dry argon in a glove box. The powder is added small amounts at a time and tamped down with a silver rod until the tube is full, at which point the tube is closed off using a

plug of silver tape. After the tube has been packed with superconducting powder and sealed, then the tube is degassed by placing it in a cool oven, in air, raising the temperature to 830°C and maintaining that temperature for five hours. The tube is then drawn in a number of stages down to a diameter of approximately 1.11 mm. The drawing is done in 27 steps in each of which the cross-sectional area of the tube is reduced by approximately 15%. During drawing, the tube is twice annealed at 500°C for between 30 and 60 seconds, when its diameter is 2.51 mm and 1.96 mm.

The 1.11 mm wire is then rolled in a rolling mill with a roll diameter of 200 mm, in stages to successive smaller thicknesses using roll gaps of 0.80, 0.65, 0.50, 0.40, 0.35, 0.30, 0.25 and 0.22 mm, twice annealing for between 30 and 60 seconds at 500°C, at thicknesses of 0.65 mm and 0.35 mm.

The tape is then cut into eight strips of equal length and stacked in two stacks as shown with one or two metal tapes (about 0.22 mm thick) as required and the stack of tapes wound on a former of ceramic material (with ceramic paper strip interleaved to prevent bonding of turns). It may be desirable to square the edges of the taps (by trimming or otherwise) before stacking to minimise risk of creating voids between the columns. The tapes are then heated at 840°C for about five hours to effect diffusion bonding and then, after being cooled to room temperature, rolled in stages to 0.32 mm using successive roll gaps of 1.00 (when there are two metal tapes), 0.80, 0.65, 0.55, 0.45, 0.38, 0.35, and 0.32 mm, annealing under the same conditions as before at 0.80 mm and 0.55 mm.

The composite tape is then heated in air, starting with a cool oven, to 840°C and held at that temperature for 50 hours, cooled to room temperature and rolled once on the same mill with a roll gap of 0.28 mm. Finally it is heat-treated in an atmosphere of 7.5% oxygen balance nitrogen, starting with a cold oven, heated to 825°C, held at that temperature for 40 hours and then cooled over a further period of 40 hours to 785°C. This heat-treatment regime serves to consolidate it, complete texturing and convert the precursor to the desired BSCCO- 2223 phase without risking melting of any large volume fraction of the superconducting material.

The embodiment described above has used eight monofilamentary constituent tapes 2 and a final thickness between 0.25 and 0.3 mm. However, more or fewer tapes

can be used and the width, thickness and number of sub-stacks varied depending upon the application of the tape and the relevant (but conflicting) requirements for capacity and flexibility. In most cases the balance of thicknesses and rolling reduction should be such that the filament thickness is generally in the range 10-40 μm, but preferably close to the lower end of that range.

Twisted (or untwisted) multifilamentary tapes, if desired with different numbers of filaments, different pitches and/or different twisting sense or direction, could also be stacked and bonded together and provided with or without the outer layers of silver/silver alloy, but the invention is not expected to show the same benefits for twisted tapes as for untwisted ones.

Although the invention has been described with reference to specific examples it will be appreciated by those skilled in the art that it may be embodied in many other forms.

CLAIMS:-

1. A composite superconducting tape comprising a multiplicity of constituent superconducting tapes stacked parallel to one another with major faces in contact, and characterised in that at least some of the constituent tapes have widths not greater than half the width of the composite superconductor and are laid edge to edge with each other.

2. A composite superconducting tape as claimed in claim 1 in which all the constituent superconducting tapes have a width that is substantially a simple fraction of the width of the composite tape so that they form two or more substacks with aligned zones between them which contain no superconducting material.

3. A composite superconducting tape as claimed in claim 2 in which the said simple fraction is a half, so that there are two sub-stacks.

4. A composite superconducting tape as claimed in any one of claims 1-3 comprising at least one full-width tape of silver or silver alloy bridging from tape to tape.

5. A composite superconducting tape as claimed in claim 4 in which two full-width metal tapes are present, one at each end of the stack.

7. A composite superconducting tape as claimed in claim 6 in which the two metal tapes are of unequal strength.

8. A composite superconducting tape as claimed in any one of claims 1-7 in which the superconducting tape is diffusion-bonded and all its elongate components extend longitudinally.

9. A composite superconducting tape as claimed in any one of claims 1-8 in which the constituent tapes are all powder-in-tube superconducting tapes.

10. A composite superconducting tape substantially as described with reference to either Figure 1 or Figure 2.

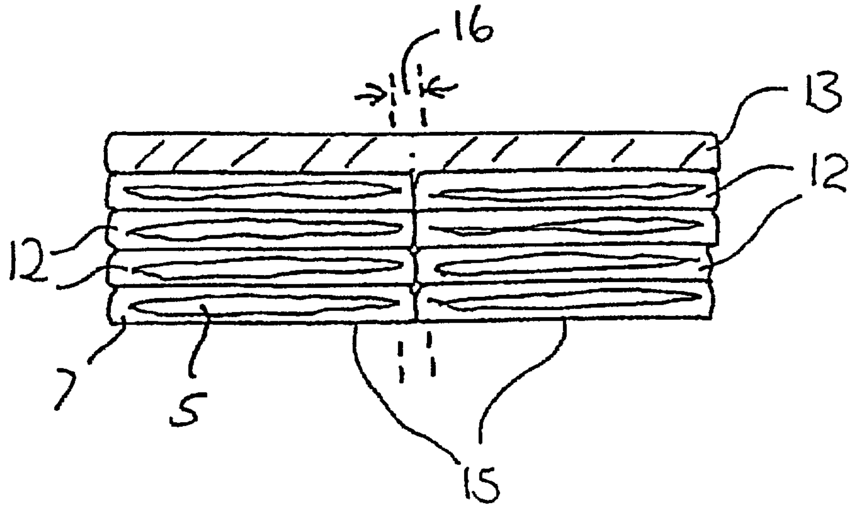

FIGURE 1

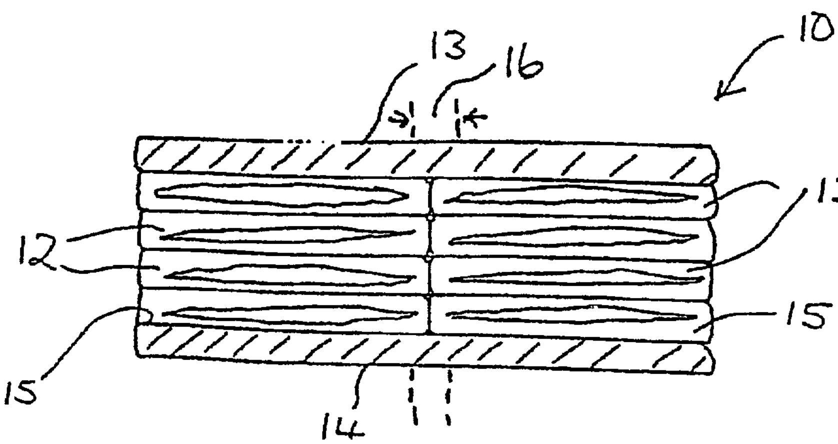

FIGURE 2